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Hult et al.

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(54) **SAFETY GUARD FOR A ROTATABLE MEMBER**

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E21B 43/00 (2006.01)
F16P 1/02 (2006.01)
F16P 1/04 (2006.01)

(52) **U.S. Cl.**
CPC ***F16P 1/02*** (2013.01); ***F16P 1/04*** (2013.01)

(58) **Field of Classification Search**
USPC 464/170, 178; 166/68.5, 67, 68, 72; 74/609
See application file for complete search history.

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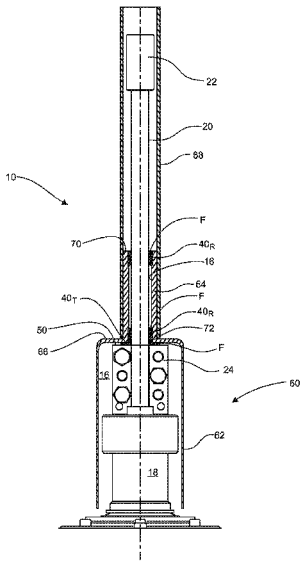
(57) **ABSTRACT**

Embodiments of a safety guard, fit concentrically over a rotating member, such as a rod assembly, which extends outwardly from apparatus, such as a drive head. The guard may be restrained during normal operation for preventing entanglement of personnel or other apparatus with the rod assembly which continues to rotate within the tubular guard, or may be unrestrained during normal operation. When unrestrained, the guard is free to co-rotate with the rod assembly, but has a low moment of inertia such that the guard decelerates rapidly when restrained so as to prevent entanglement. An anti-friction interface between the guard and the rod assembly is formed by the material of manufacture of the guard itself or by bearings or bushings supported in an annulus between the guard and the rod assembly.

11 Claims, 13 Drawing Sheets



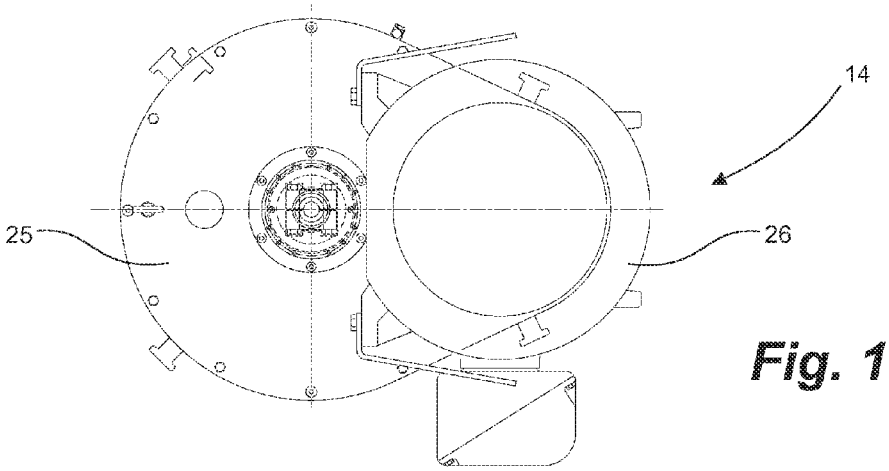
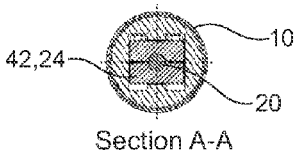


Fig. 1C

Fig. 1D



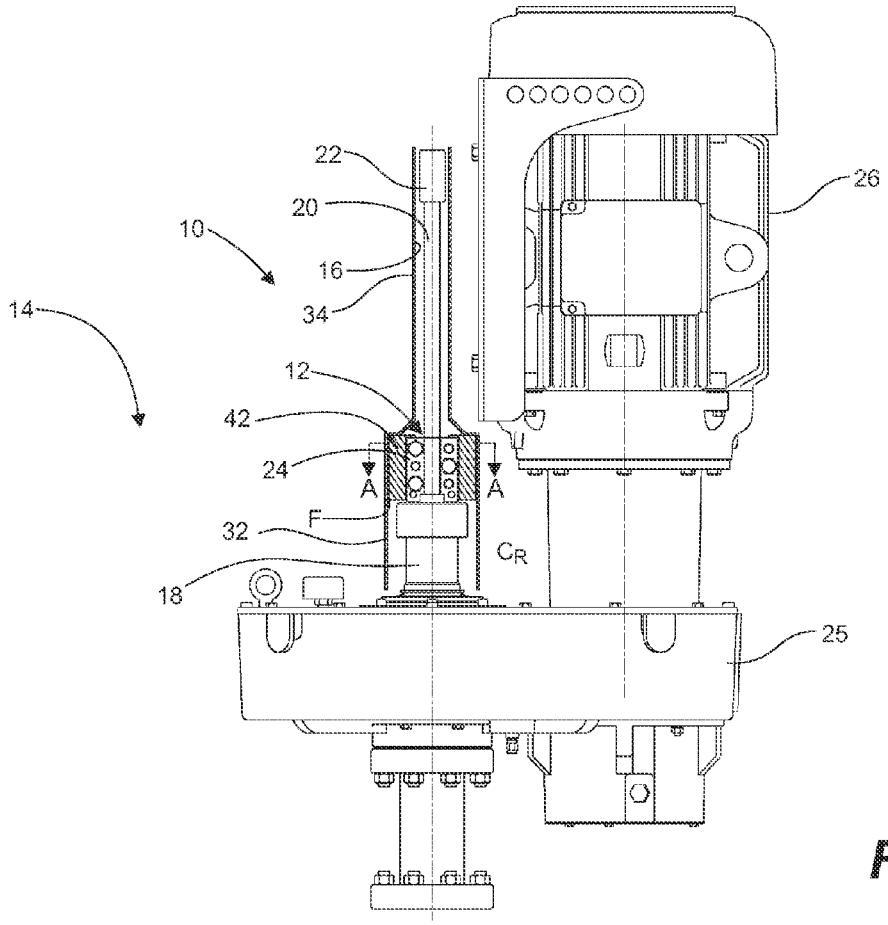


Fig. 1A

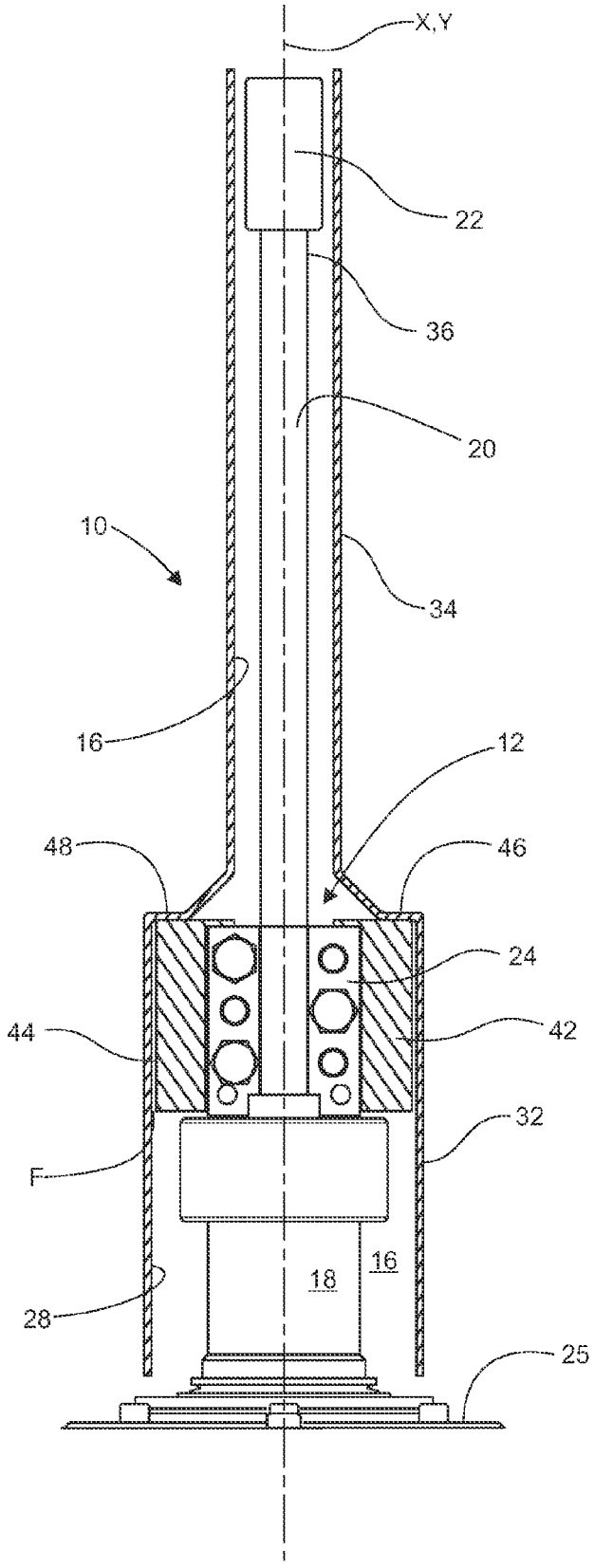


Fig. 1B

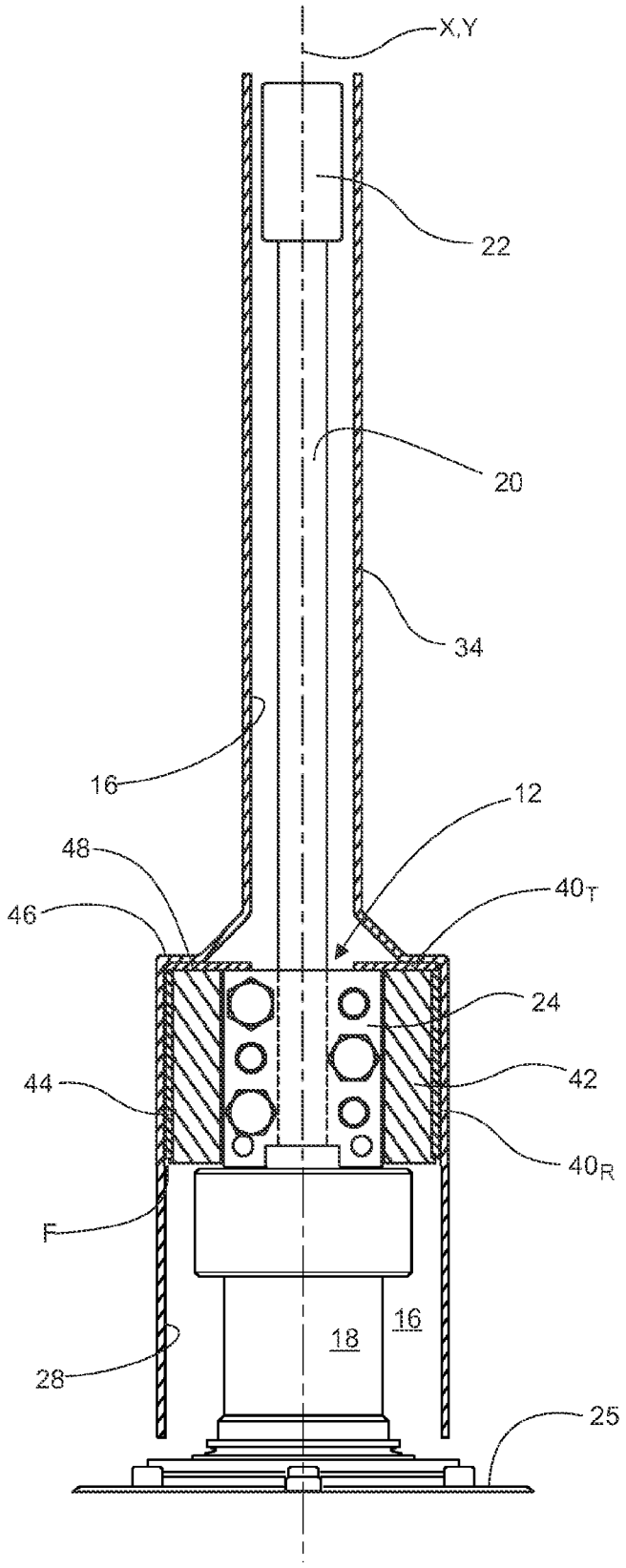


Fig. 2

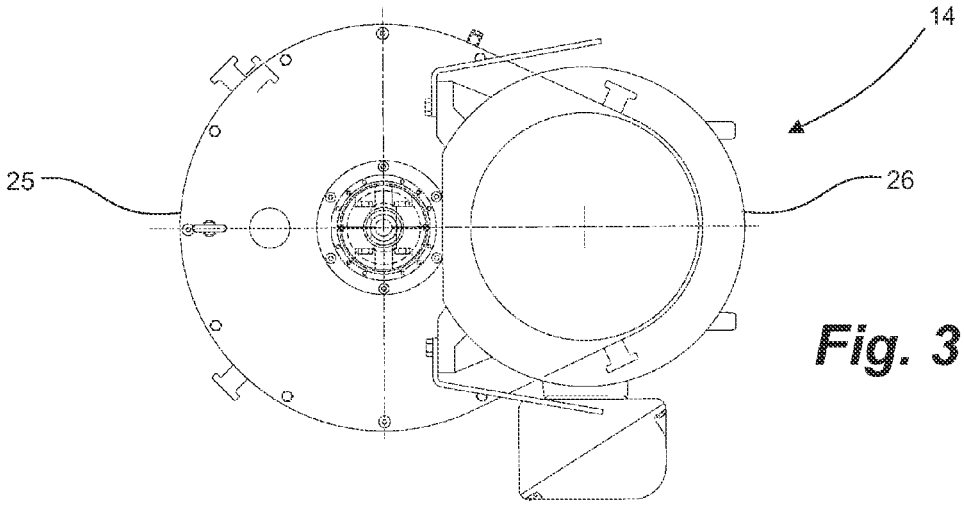
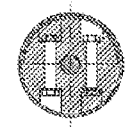


Fig. 3C

Fig. 3D



Section A-A

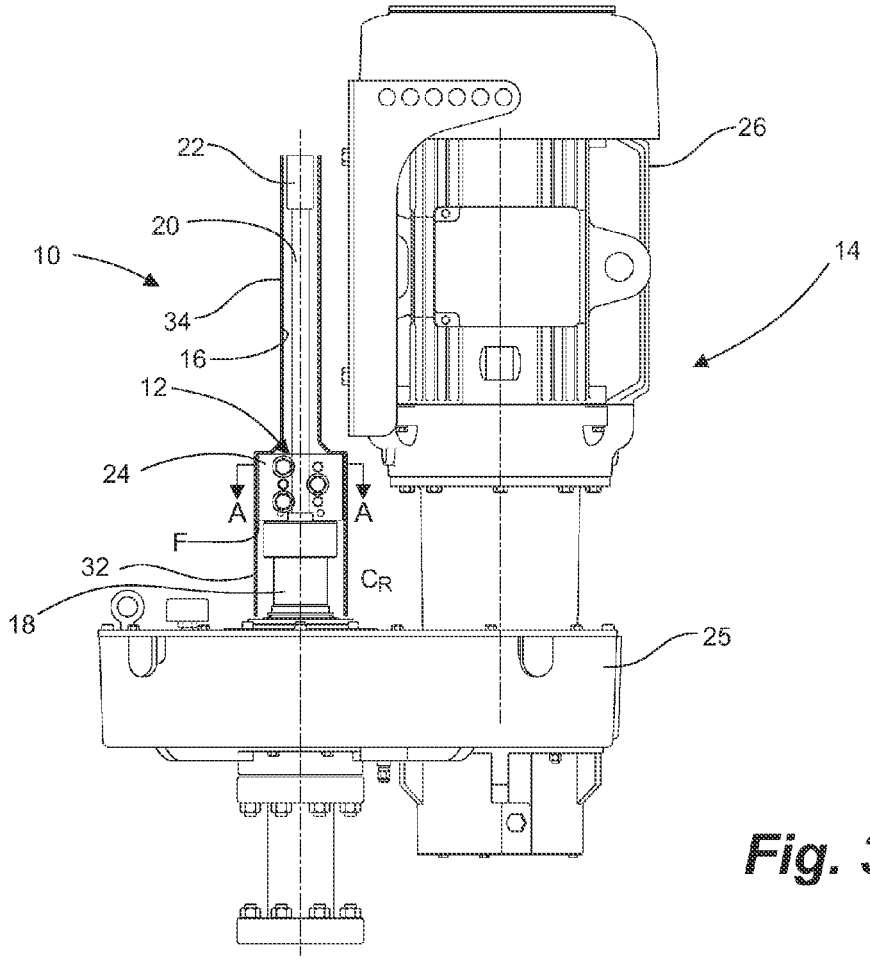


Fig. 3A

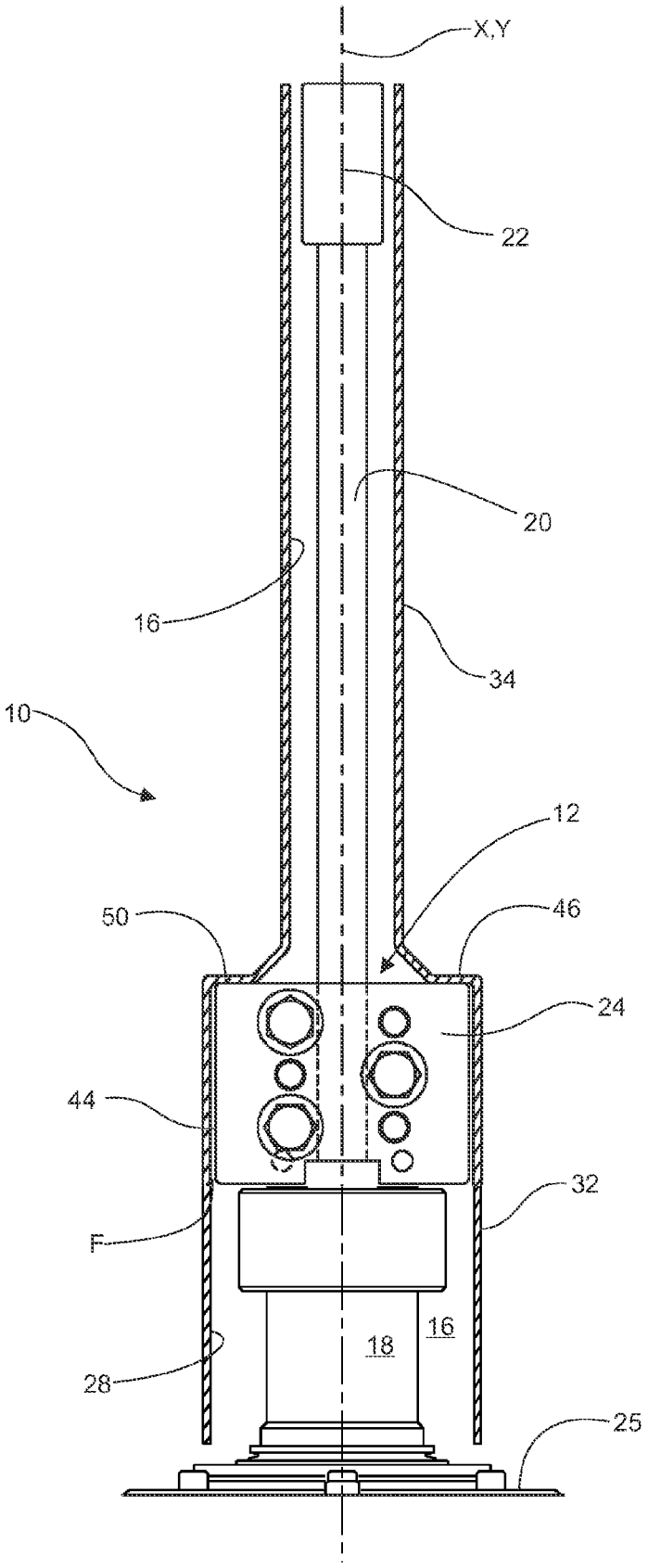


Fig. 3B

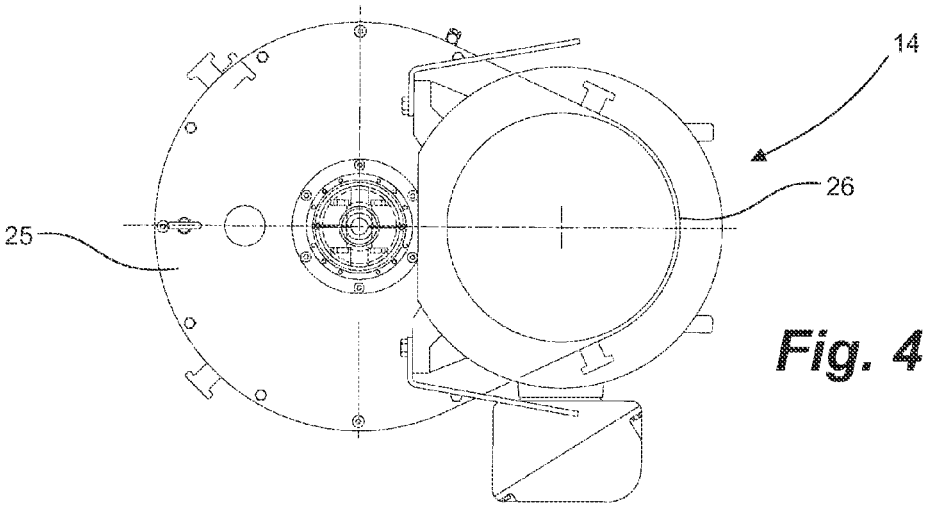


Fig. 4C

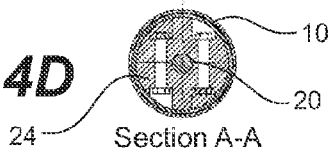


Fig. 4D

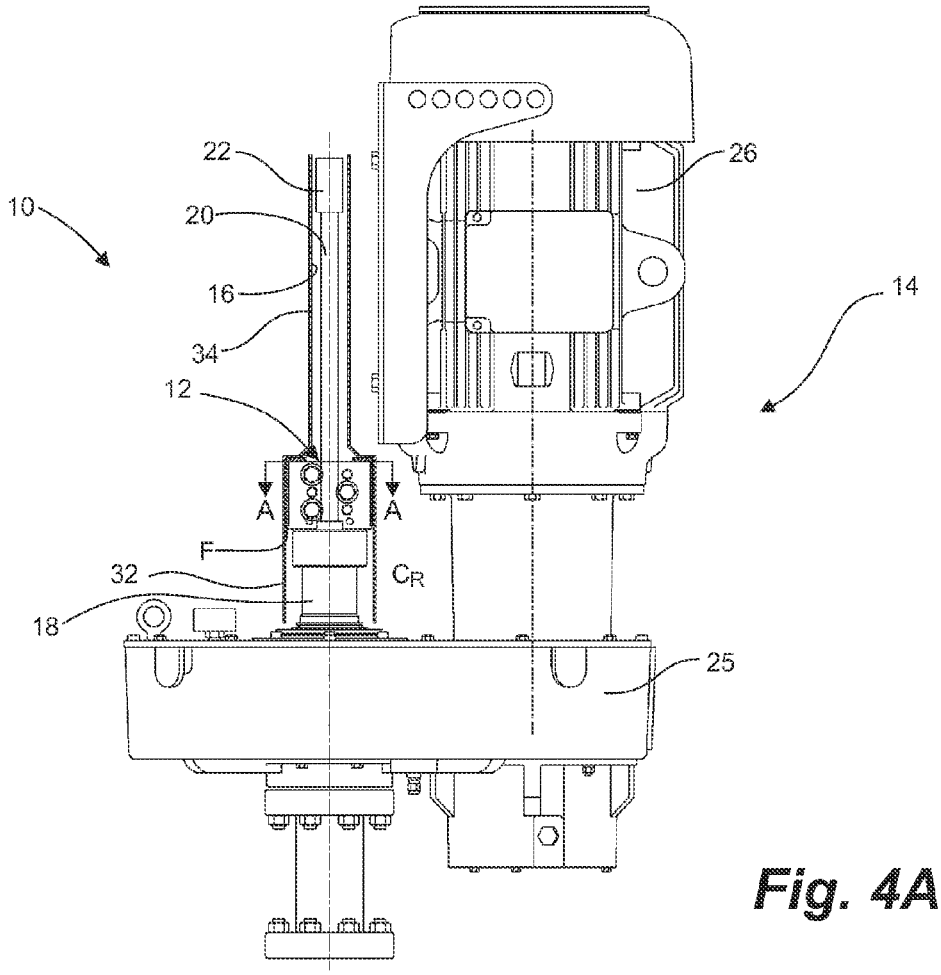


Fig. 4A

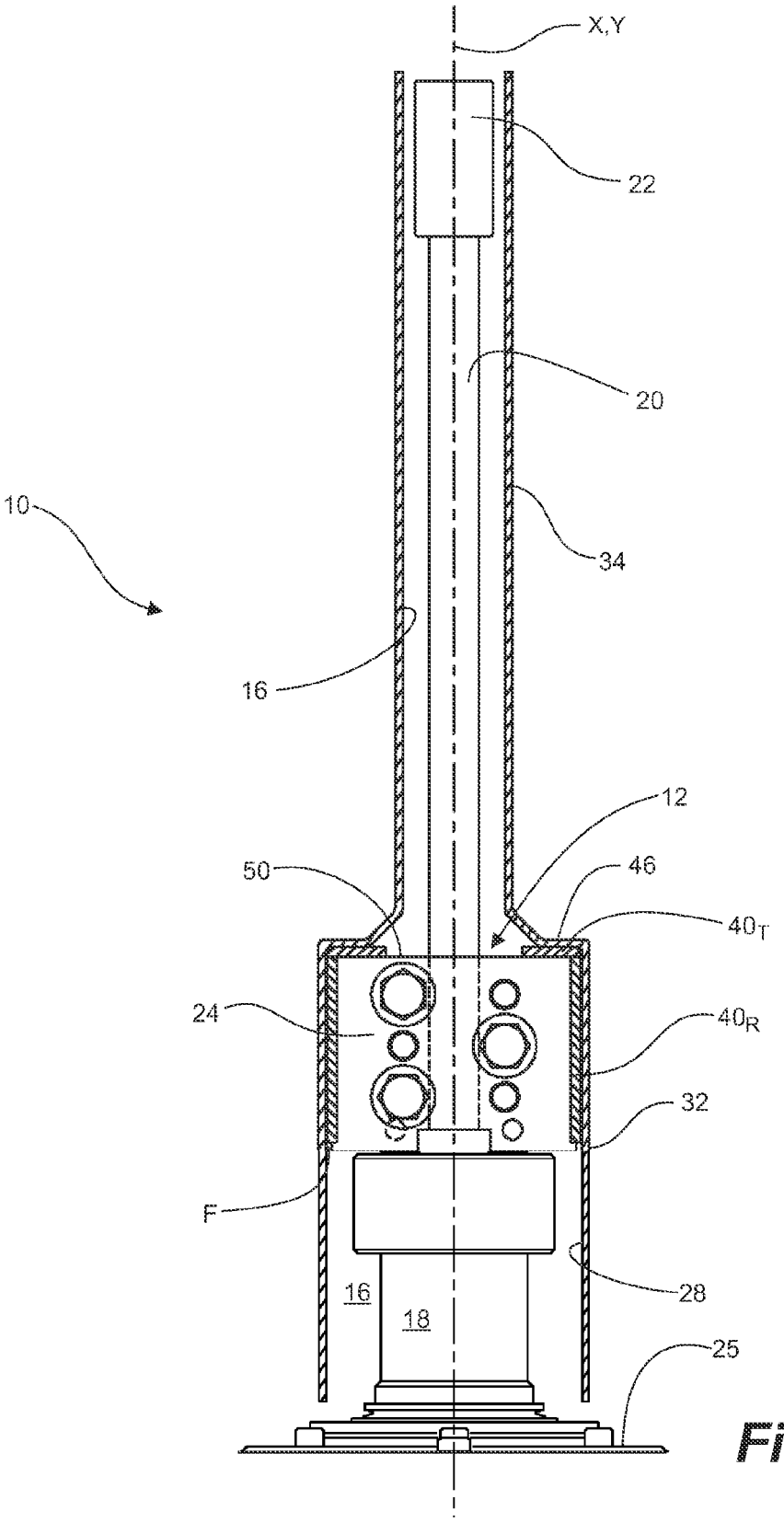


Fig. 4B

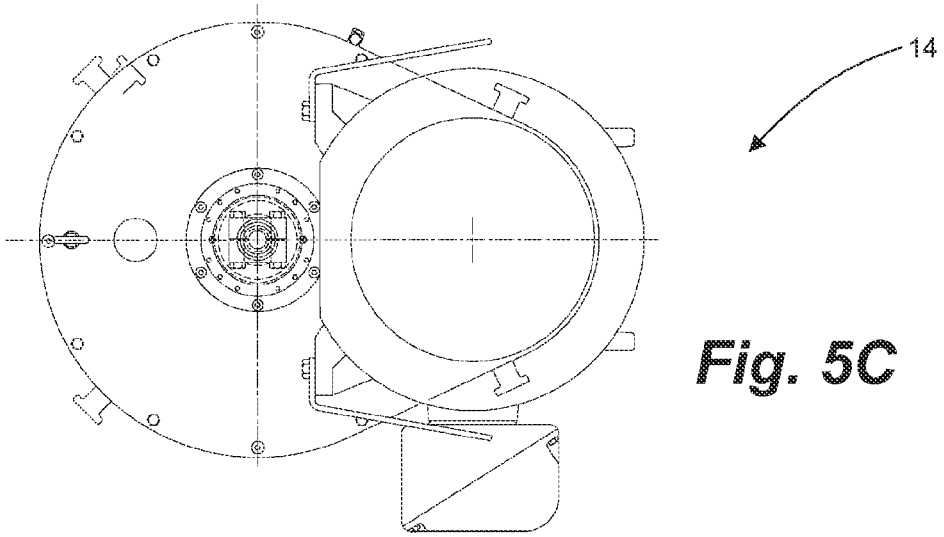


Fig. 5C

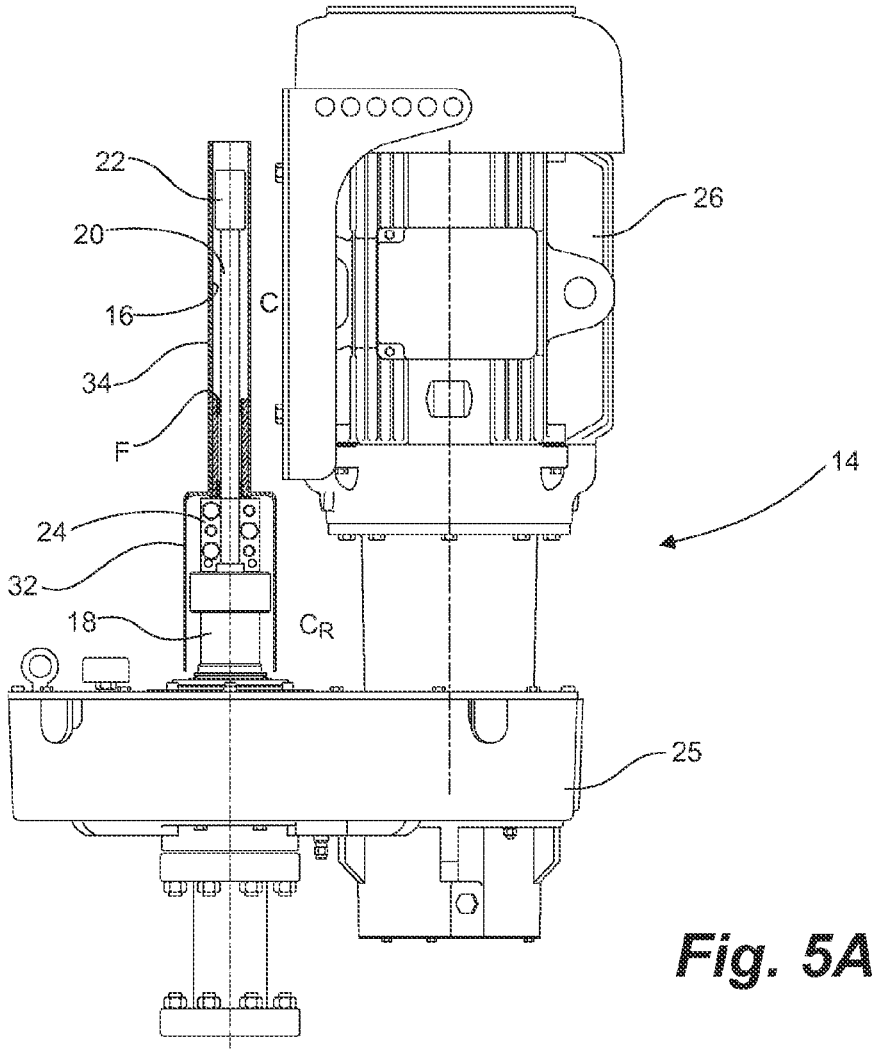


Fig. 5A

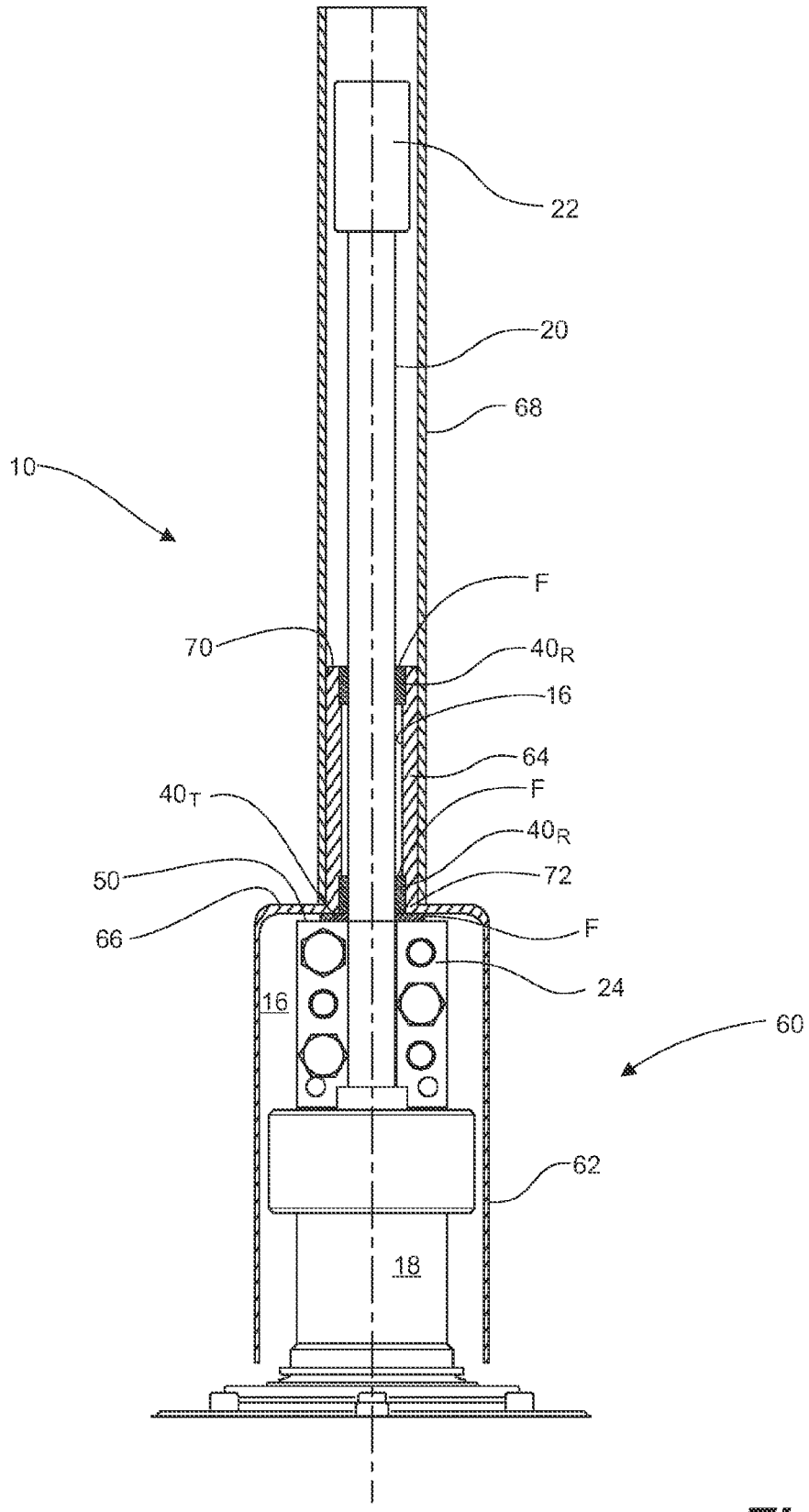


Fig. 5B

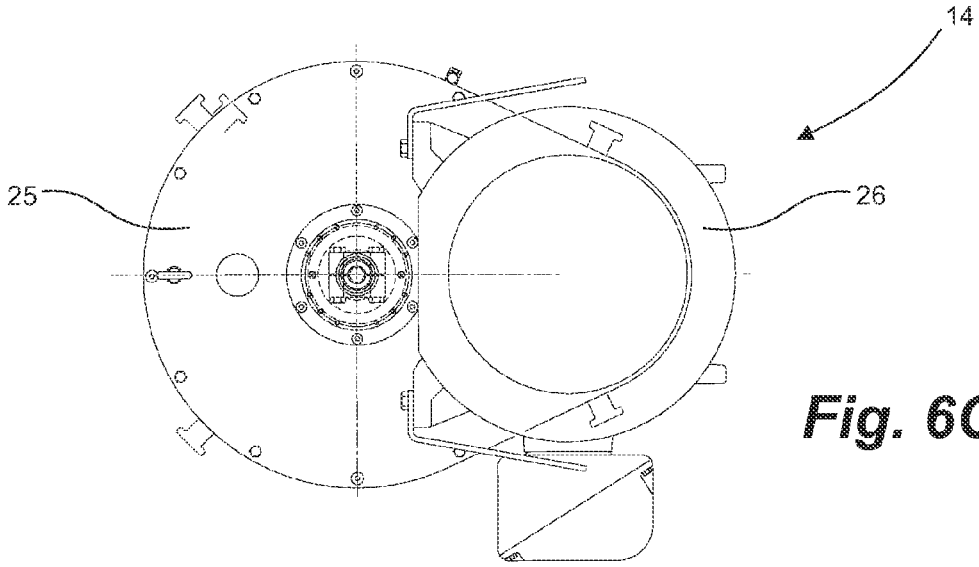


Fig. 6C

Fig. 6D

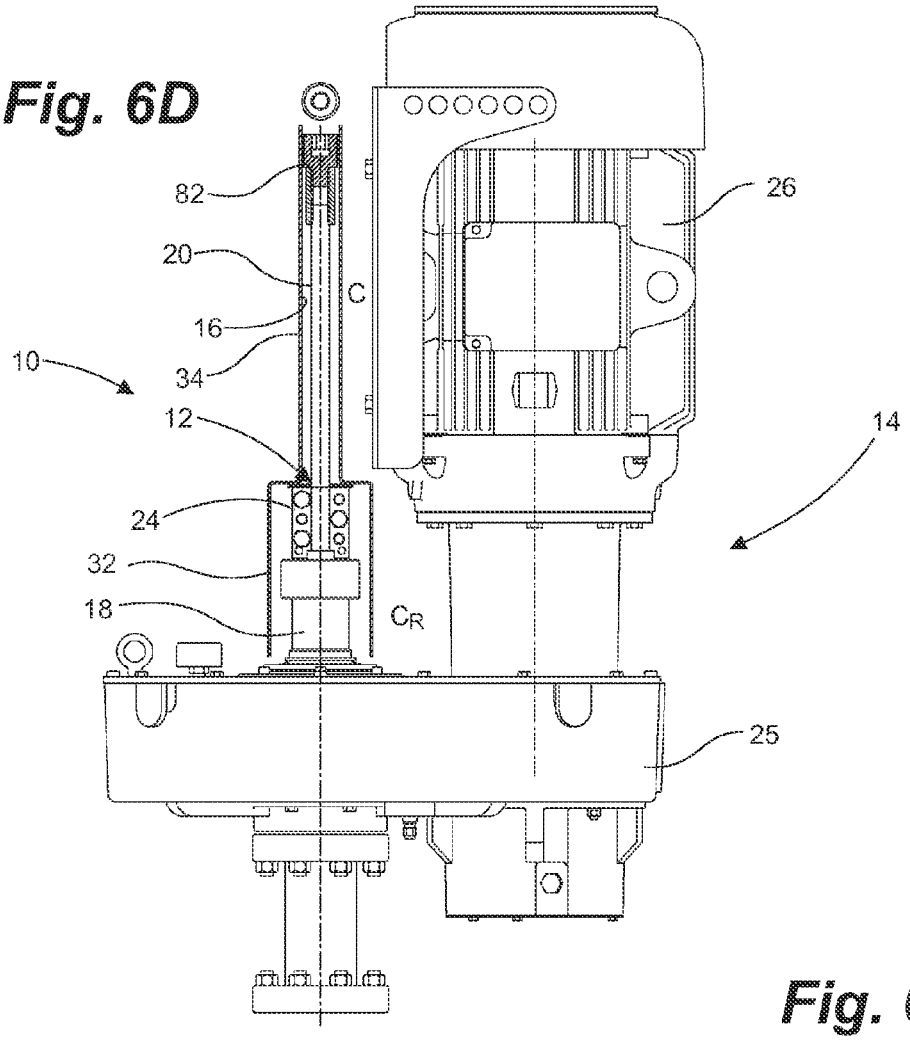


Fig. 6A

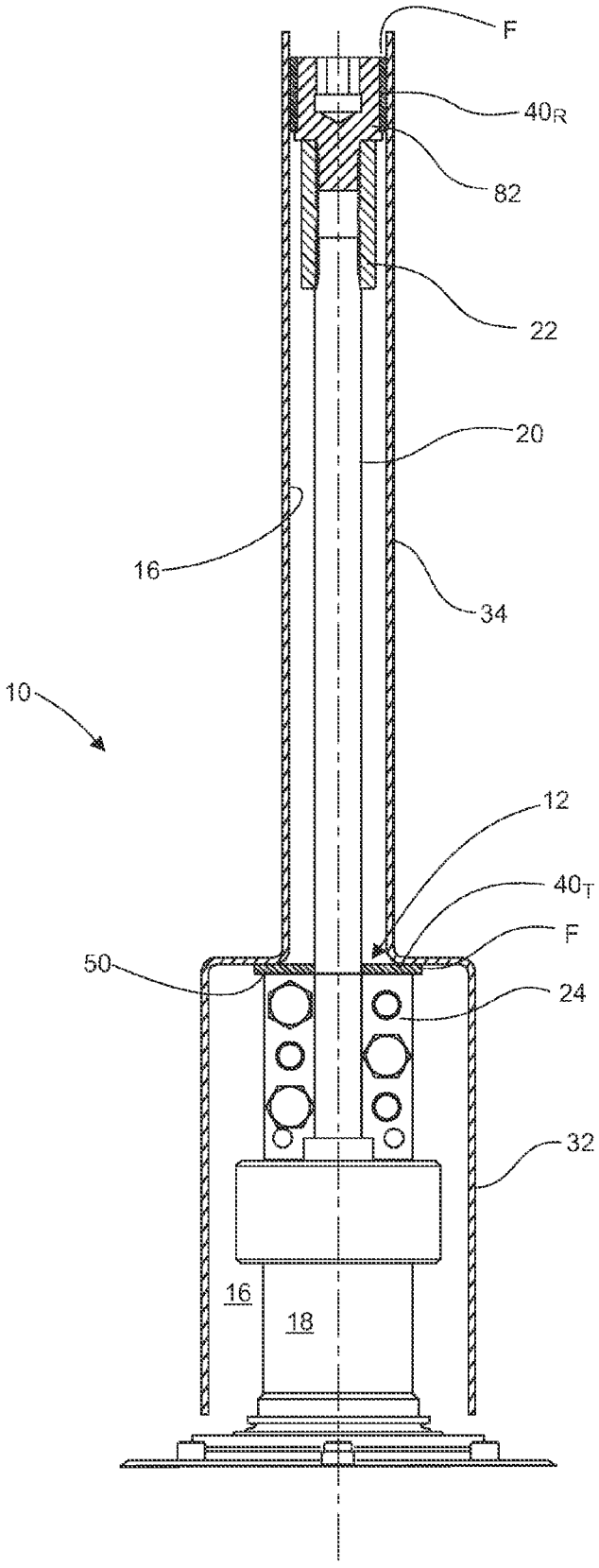


Fig. 6B

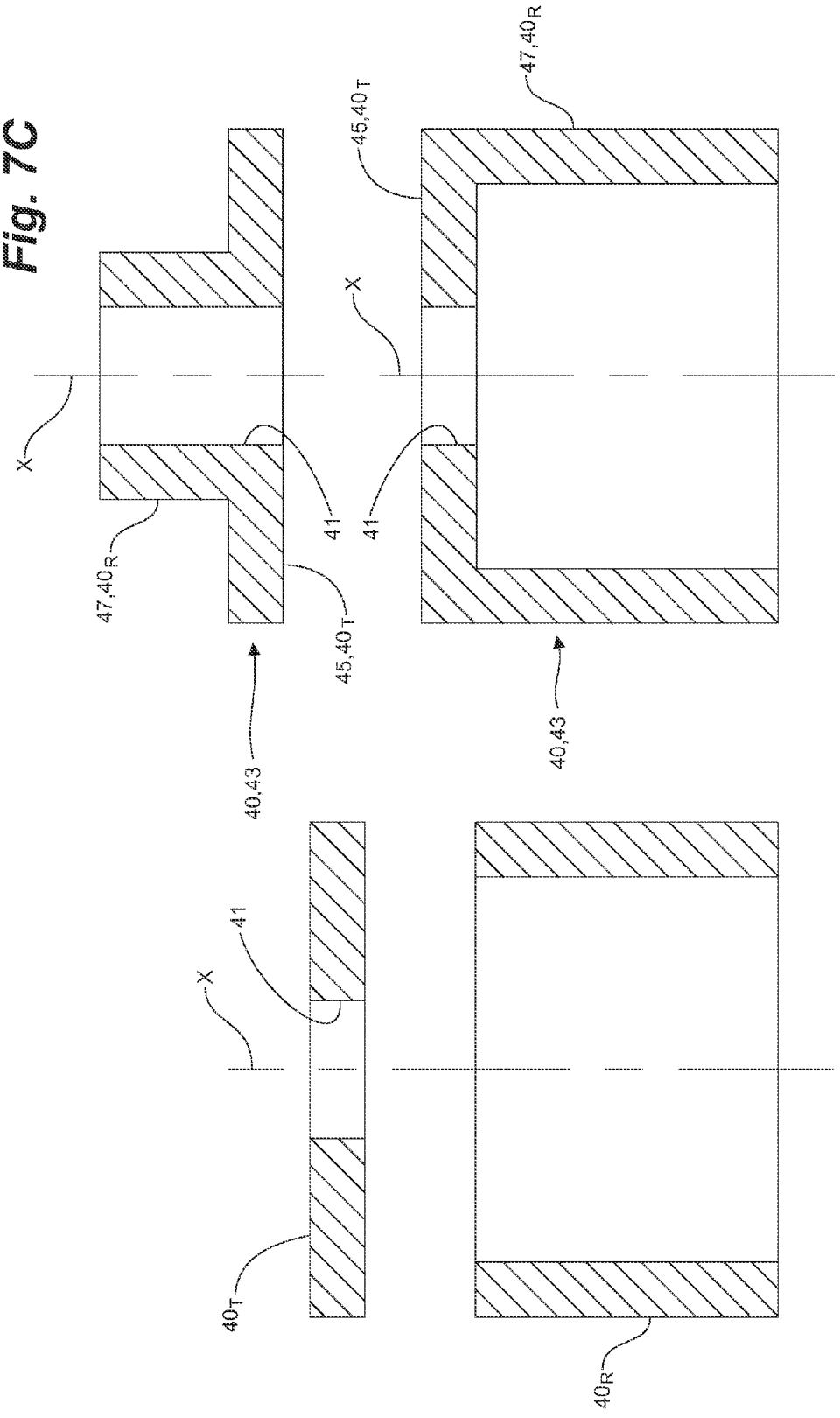


Fig. 7A

Fig. 7B

Fig. 7C

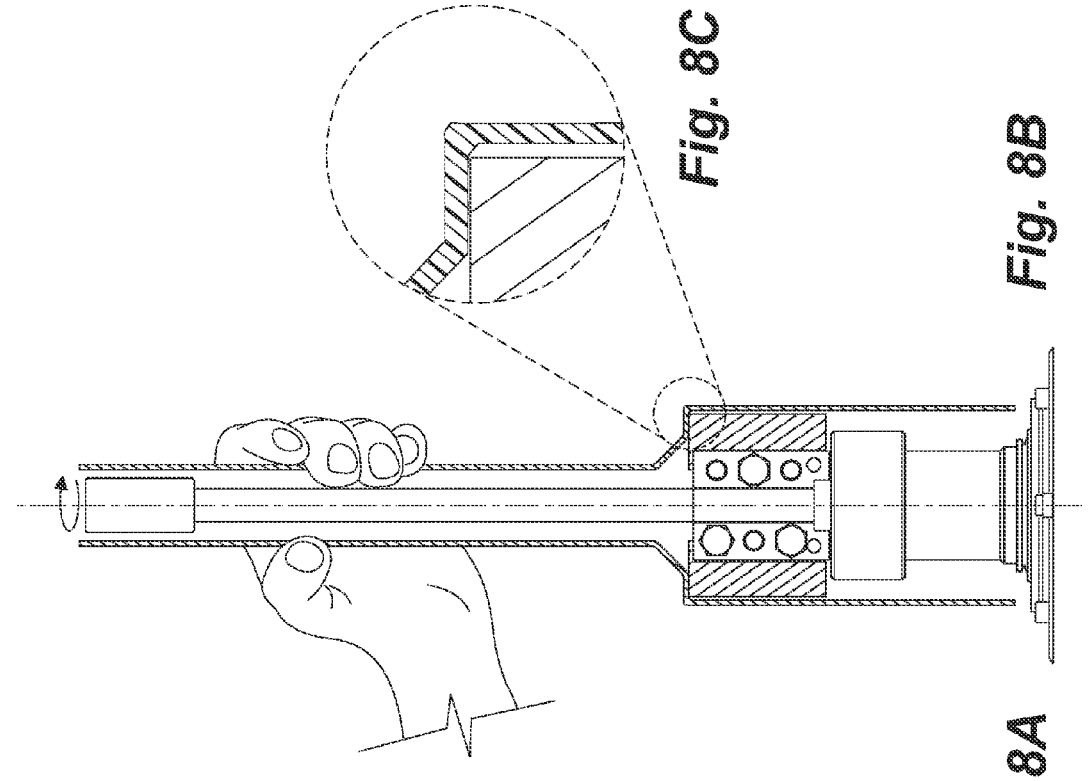


Fig. 8C

Fig. 8B

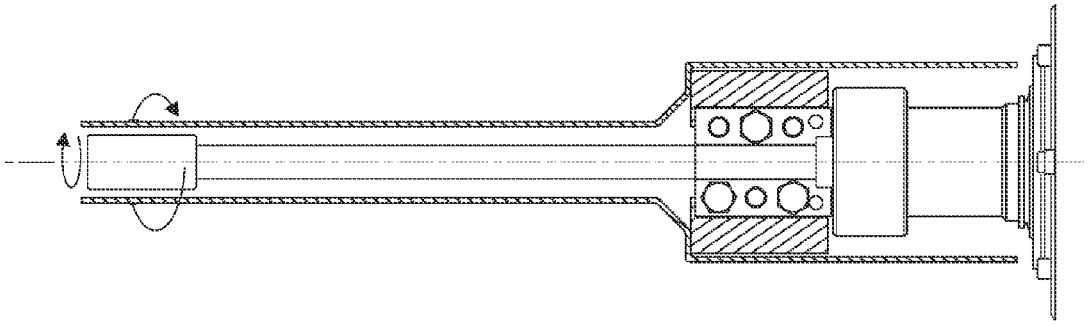


Fig. 8A

SAFETY GUARD FOR A ROTATABLE MEMBER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a regular application claiming priority of U.S. provisional application 61/675,212, filed Jul. 24, 2012, the entirety of which is incorporated herein by reference.

FIELD OF THE DISCLOSURE

Embodiments of the disclosure relate to safety equipment to prevent entanglement with a moveable element, such as a rotatable driven member, and more particularly, to safety apparatus for preventing injury resulting from contact with a rotating, driven rod extending outwardly from a drive head.

BACKGROUND

It is well known that there are many safety concerns when working in the vicinity of moving equipment, particularly in industries such as the oil and gas industry. Precautions are taken to ensure that personnel working with, or near such equipment are protected from directly engaging and becoming entangled in the moving apparatus. Guards are placed over the moving parts.

In the case of progressing cavity pumps, a polished or coiled rod is connected to a main shaft of a drive head at surface, for rotating a rod string and rotor connected thereto, for driving the pump downhole. The rotatable rod typically extends above a rod clamp on the drive head at surface. The rod rotates with the driven main shaft.

It is known to provide a fixed safety guard to surround or enclose the exposed portion of a polished rod. Thus, the guard prevents accidental engagement with a rotating polished rod. The energy in the rotating polish rod and supported drive string is significant and rotation takes some time to arrest. Thus, by preventing contact with the rod string, injury to personnel and damage to the surface of the polished rod is minimized.

Tubular, fixed guards are known. Typically, the guard is a metal mesh or solid plastic tube which has a fixed diameter that is significantly larger than both the main shaft and the polished rod clamp to avoid engaging either the shaft or the rod during rotation. The prior art guards are affixed to the drive head, such as to a top of the gearbox and remain stationary. In drive heads where the motor is affixed to the top of the gearbox, the motor must be spaced sufficiently from the main shaft and polished rod clamp to permit mounting the guard therebetween. This may result in a larger drive head than would otherwise be required or prevent proper installation of the guard at all. Further, fixed guards must typically be custom-made for the drive head to enable affixing thereto.

There is interest in the industry for a universal safety means to prevent or minimize contact with polished rod, main shaft and polished rod clamp while maximizing space in the drive head for mounting the motor and the like.

SUMMARY

Embodiments of a safety guard and system disclosed herein comprise a tubular guard which is supported concentrically over a driven member and substantially prevents injury to personnel and equipment by preventing entanglement with the driven member.

In embodiments, the guard is restrained during normal operation. An anti-friction interface formed within an annulus between the guard and the driven member enables differential rotation therebetween.

In embodiments where the guard is unrestrained during normal operation, the guard is free to co-rotate with the driven member. The guard has a moment of inertia such that when restrained the guard slips to decelerate rapidly enabling the driven member to rotate within the guard. The rapid deceleration minimizes contact injury or secondary entanglement with the co-rotating guard as it slips and even slows to a stop. The anti-friction interface formed within an annulus between the guard and the driven member enables this differential rotation therebetween when the guard is restrained. In the case of a rotating polished rod or coiled rod, the guard is fit about the rod extending from apparatus such as a drive head or rod string. The guard is fit to the driven member regardless of the size, make or configuration of the drive head.

In a broad aspect, a safety guard for preventing entanglement by contact with a rotatable driven member comprises a tubular guard positioned concentrically about the driven member and forming an annulus therebetween. An anti-friction interface is formed within the annulus for enabling differential rotation between the guard and the driven member, if and when the guard is restrained.

In embodiments, the guard is restrained from rotation during normal operations. In other embodiments the guard is unrestrained in normal operations is free to co-rotate with the driven member. The guard has a low moment of inertia, so that when restrained by contact therewith, rotation of the guard decelerates while the driven member continues to rotate therein.

Embodiments are particularly suitable for use with oilfield equipment such as a rotating rod assembly which extends outwardly from a drive head, the rotating rod assembly driving a downhole pump.

In another broad aspect, a system for preventing entanglement by contact with a rotating rod assembly for driving a downhole pump, comprises a drive head having a housing from which the rotating rod assembly extends. A tubular guard is positioned concentrically about at least the rotating rod assembly and forms an annulus therebetween. An anti-friction interface is formed within the annulus for enabling differential rotation between the guard and the rotating rod assembly.

In embodiments, the guard is restrained from rotation during normal operations.

In other embodiments, the guard is unrestrained in normal operations and is free to co-rotate with the driven member. The guard has a low moment of inertia. When restrained by contact therewith, rotation of the guard decelerates while the driven member continues to rotate therein.

In an embodiment the rod assembly comprises a rotating rod and a rod clamp for operatively connecting the rotating rod to a main driven shaft extending upwardly from the housing and being rotatable therewith. A drive is operatively connected to the main shaft for driving the pump. The drive extends upwardly from the housing adjacent to the rod assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a partial cross-sectional view of a safety guard according to one embodiment, the safety guard being mounted to a polish rod assembly for co-rotation therewith and shown in relation to a gearbox and motor of a drive head;

FIG. **1**B is a detailed cross-sectional view of the safety guard according to FIG. **1**A;

FIG. **1**C is a plan view according to FIG. **1**A;

FIG. **1**D is a cross-sectional view of the guard and rod assembly along section lines A-A of FIG. **1**A;

FIG. **2** is a detailed cross-sectional view of a safety guard according to another embodiment;

FIG. **3**A is a partial cross-sectional view of a safety guard according to another embodiment;

FIG. **3**B is a detailed cross-sectional view of the safety guard according to FIG. **3**A;

FIG. **3**C is a plan view according to FIG. **3**A;

FIG. **3**D is a cross-sectional view of the guard and rod assembly along section lines A-A of FIG. **3**A;

FIG. **4**A is a partial cross-sectional view of a safety guard according to another embodiment;

FIG. **4**B is a detailed cross-sectional view of the safety guard according to FIG. **4**A;

FIG. **4**C is a plan view according to FIG. **4**A;

FIG. **4**D is a cross-sectional view of the guard and rod assembly along section lines A-A of FIG. **4**A;

FIG. **5**A is a partial cross-sectional view of a safety guard according to another embodiment;

FIG. **5**B is a detailed cross-sectional view of a two-part safety guard according to FIG. **5**A;

FIG. **5**C is a plan view according to FIG. **5**A;

FIG. **6**A is a partial cross-sectional view of a safety guard according to another embodiment;

FIG. **6**B is a plan view according to FIG. **6**A;

FIG. **6**C is a cross-sectional view along section lines A-A of FIG. **6**A;

FIG. **6**D is a detailed cross-sectional view according to FIG. **6**A, a motor and gearbox having been removed for enlarging the view of the safety guard for clarity;

FIG. **7**A is a cross-sectional view of a thrust bearing and a radial bearing used in embodiments disclosed herein;

FIG. **7**B is a cross sectional view of an integrated bearing formed from a radial bearing and a thrust bearing, such as for use in the embodiments shown in FIGS. **2** and **4**B;

FIG. **7**C is a cross-sectional view of another integrated bearing for use in the embodiment shown in FIG. **5**B;

FIG. **8** is a detailed cross-sectional view of the safety guard according to FIG. **1**A illustrating co-rotation between the safety guard and the driven rotatable member;

FIG. **8**B is a detailed cross-sectional view of the safety guard according to FIG. **8**A illustrating deceleration and cessation of rotation of the safety guard and continued rotation of the driven rotatable member when the safety guard is restrained; and

FIG. **8**C is a detailed cross-sectional view of according to a portion of FIG. **8**B illustrating manufacture of the safety guard from plastic or PTFE.

DETAILED DESCRIPTION

Having reference to FIGS. **1**A to **6**D, in embodiments described herein, tubular safety guards **10** are positioning concentrically about a driven, rotatable member **12**, extending outwardly from apparatus **14**. The guard **10** is supported by the driven member **12** spaced from the apparatus **14**. An anti-friction interface F is formed in an annulus **16** between the rotatable member **12** and the guard **10**. Being supported by the driven member **12**, the guard **10** is independent of the apparatus **14**.

According to various embodiments described herein, and shown in FIGS. **8**A and **8**B, when the safety guard **10** is in normal operation, that is during normal operation where the guard **10** is not engaged, encumbered or otherwise restrained from rotation, the guard **10** is free to co-rotate with the driven member **12** (FIG. **8**A). However, when restrained, such as being grabbed or contacted in any manner by personnel, other apparatus or the like, the guard **10** decelerates to a stop, halting or arresting rotation of the guard **10** while rotation of the driven member **12** continues therein (FIG. **8**B). The guard **10** is generally lightweight and has a low moment of inertia such that when restrained the guard **10** stops quickly, restrained from rotation despite continued rotation of the driven member **12**. Thus, entanglement with the driven member **12** is prevented.

In embodiments, the rotatable member **12** is a rod assembly, being either a coiled rod or a polished rod assembly. The rod assembly **12** typically comprises a main driven shaft **18**, a polished or coiled rod **20** and couplings **22** affixed thereto, and a rod clamp **24** which connects and supports the driven, rotatable rod **20** to the main shaft **18**, or the like. The rod assembly **12** extends upwardly from the drive head **14**, typically from a housing **25**, such as a gear box or stuffing box. A drive **26** is operatively connected to at least the main shaft **18** for driving a rod **20**, a rod string and downhole pump connected thereto (not shown). The drive **26** may also extend upwardly from the gear box **14**.

While those of skill in the art will understand that the rotatable member **12** can be any driven member, including a shaft, a coiled rod assembly or a polished rod assembly, for ease of description, embodiments herein are described in the context of a polished rod assembly.

A rotor and polished rod of a conventional progressive cavity pump (PC pump) are typically rotated at less than about 700 rpm. The rotational speeds are even slower as the viscosity of the fluid to be pumped increases. Rotational speeds of less than 100 rpm are not typically used. As one of skill in the art can see, when the guard **10** is restrained and decelerated to a stop, the differential rotational speeds are not high.

The antifriction interface F acts to minimizes friction between the guard **10** and the polished rod assembly **12**.

In embodiments, best seen in FIGS. **1**B, **3**B and **8**C, a material of manufacture of the guard **10** or at least an inner surface **28** thereof, forms the anti-friction interface F. The use of various plastic materials in the manufacture of the guard **10**, such as polytetrafluoroethylene (PTFE), reduce the coefficient of friction.

In embodiments best seen in FIGS. **2**, **4**B, **5**B and **6**B, the anti-friction interface F may comprise intermediate bushing or bearings **40** operatively supported in the annulus **16**, alone or in combination with friction-reducing plastic material, to reduce the degree of friction produced.

Where the drive **26** is adjacent to and extends upwardly from the gear box **14**, typically along an axis parallel to that of the rod assembly **12**, the drive **26** may encroach upon a clearance C about the rod assembly **12**, and the guard **10** which is operatively connected thereto, as described below. In embodiments, the guard **10** is profiled for conforming to and fitting concentrically over the polished rod assembly **12** for minimizing a diameter of at least a portion of the guard **10** so as to be accommodated and rotatable within the encroached clearance C. Thus, interference between the guard **10** and the adjacent drive **26** is minimized.

In embodiments shown in FIGS. **1**A to **6**D, the profiled guard **10** comprises a larger diameter, lower portion **32**, for fitting over the main shaft **18** and the polished rod clamp **24**, and a smaller diameter, upper portion **34**, for fitting over the polished rod **20**. The upper portion **34** extends upwardly from the polished rod clamp **24**, sized to accommodate the smaller

diameter polish rod **20**. The upper portion **34** also extends about a polished rod coupling **22** connected to a top end **36** of the polished rod **20**. A radially extending shoulder **46** connects the upper and lower portions **34**,**32**.

Conveniently, there is typically a generous radial clearance or recess C_R formed about the polish rod clamp **24**, between the gearbox **14** and the parallel and adjacent drive **26**, mounted thereabove. Advantageously, the larger diameter, lower portion **32** typically extends into the typical recess C_R existing between the gearbox **14** and the drive **26**.

As shown in FIGS. **1**A-**1**B and **3**A-**3**B, wherein the anti-friction interface F generally results from the material of manufacture of the guard **10** or the inner surface **28** thereof, the guard **10** is rotationally supported directly on the polished rod assembly **12** for normal co-rotation therewith and differential rotation when restrained. An axis of rotation X of the guard **10** is concentric with an axis of rotation Y of the polished rod assembly **12**. The guard **10** is supported to minimize angular misalignment, wobbling or tipping. In embodiments, the guard **10** is supported at the polished rod clamp **24**, to both accept axial loading, such as the weight of the guard **10**, and radial loading applied thereto, while permitting relative rotation of a restrained guard **10** about the rotating polish rod clamp **24**.

Optionally, as shown in FIGS. **2**, **4**A-**4**B, **5**A-**5**B and **6**A-**6**B, bushings or bearings **40** or a combination thereof, referred to herein collectively as bearings, are operatively connected in the annulus **16** between the guide **10** and the polished rod assembly **12** to accept radial and axial loads imposed therebetween.

Having reference again to FIGS. **1**A-**1**D and in one embodiment of a system comprising the guard **10** and the rod assembly **12**, the polished rod clamp **24** is typically square or rectangular in cross-section. To accommodate various rod clamps **24**, a generally circular adapter sleeve **42**, such as a cast sleeve, is fit about the non-circular rod clamp **24** for forming an outer cylindrical surface **44** thereabout. The sleeve **42** has an inner profile which corresponds to the non-circular cross-section of the rod clamp **24**. The outer cylindrical surface **44** of the sleeve **42** forms a bearing surface or supports a bearing surface thereon, being the anti-friction interface F, for accepting at least the radial loads imparted thereto. The radially extending shoulder **46** formed between the guard's smaller diameter upper portion **34** and the larger diameter lower portion **32** engages a top **48** of at least the sleeve **42** which acts to accept axial loading thereon.

Having reference to FIGS. **2** and **7**A, a radial bearing $\mathbf{40}_R$ is supported in the annulus **16**, mounted between the cylindrical outer surface **44** of the cast sleeve **42** and the guard **10**. The bearing $\mathbf{40}_R$ forms the anti-friction interface F and accepts radial loading therebetween. A thrust bearing $\mathbf{40}_T$ supported in the annulus **16** between the top **48** of the sleeve **42** and the guard's radially extending shoulder **46** supports axial loading thereon. Best seen in FIG. **7**A, the radial bearing $\mathbf{40}_R$ is generally a tubular bearing or bushing and the thrust bearing $\mathbf{40}_T$ is a washer having a rod passage **41** at the rotational axis X.

Having reference to FIGS. **3**A-**3**D, the polished rod clamp **24** is a generally cylindrical clamp having the outer cylindrical surface **44** thereon which acts to accept radial loading between the guard **10** and the polished rod clamp **24**. The cylindrical surface **44** engages the larger diameter, lower portion **32** of the guard **10** for accepting the radial loading. The radially extending shoulder **46** formed between the smaller diameter upper portion **34** and the larger diameter lower portion **32** of the guard **10** engages a top **50** of the cylindrical clamp **24** which acts to accept axial loading thereon.

As shown in FIGS. **4**A-**4**D, in the embodiment of FIGS. **3**A-**3**D, a thrust bearing $\mathbf{40}_T$ is supported between the top **50** of the cylindrical polished rod clamp **24** and the shoulder **46** of the guard **10** for forming the anti-friction interface F. A radial bearing $\mathbf{40}_R$ is supported between the cylindrical surface **44** of the polished rod clamp **24** and the lower portion **32** of the guard **10** for supporting radial loading and forming the anti-friction interface F.

In embodiments, the guard **10** is generally installed by slipping the guard **10** axially over the entirety of the polished rod assembly **12**. The guard **10** is supported on the rod clamp **24** above the drive head **14** for rotation thereabove when unrestrained.

For ease of manufacture, installation and retrofit, as shown in FIGS. **5**A-**5**C, the guard **10** can be manufactured as a two-piece guard **10**. In this case, a lower tubular member **60** is a separate, profiled tubular which comprises a lower tubular portion **62** having a diameter for fitting over at least the rod clamp **24** and the main shaft **18**. A relatively short, upper tubular extension **64** extends upwardly from the lower portion **62** and has a smaller diameter for fitting over a portion of the rod **20**. A radially extending shoulder **66** is formed between the lower portion and upper extension **62**,**64**. An upper tubular member **68** has a diameter sized so as to fit over the lower member's tubular extension **64** and about the remainder of the rod **20**. The upper tubular member **68** is press-fit or friction-fit over the lower member's upper extension **64** for retaining the upper tubular member **68** on the lower tubular member **60**.

The anti-friction interface F is formed by radial bearings $\mathbf{40}_R$ in the portion of the annulus **16** between the tubular extension **64** and the rod **20** and thrust bearings $\mathbf{40}_T$ in the portion of the annulus **16** between the lower member **62** and the rod clamp **24**. Two radial bearings $\mathbf{40}_R$ may be used, one adjacent a top end **70** of the tubular extension **64** and one adjacent a bottom end **72** thereof. Thrust bearings $\mathbf{40}_T$ are supported between the shoulder **66** and the top **50** of the polished rod clamp **24**.

Having reference to FIGS. **6**A-**6**D, and best seen in FIG. **6**B, in another embodiment, the anti-friction interface F is formed by a radial bearing $\mathbf{40}_R$ supported in the annulus **16** between the upper portion **34** of the guard **10** and the top end **36** of the rod **20**, such as about a bearing adapter **82** fit to a top **84** of the polished rod coupling **22** at the top end **36** of the polished rod **20**. The thrust bearing $\mathbf{40}_T$ is supported on the top **50** of the rod clamp **24**, which may be a square or rectangular clamp **24**.

Having reference again to FIGS. **2**, **4**B, **5**B and to FIGS. **7**B-**7**C, in another embodiment, the radial and thrust bearings $\mathbf{40}_R$,$\mathbf{40}_T$ can be integrated into a single bearing **40**. The single bearing **40** can be used between the shoulder **46**,**66** of the guard **10**, and the rod clamp **24** or rod **20**, in place of separate radial and thrust bearings $\mathbf{40}_R$, $\mathbf{40}_T$.

Best seen in FIGS. **7**B and **7**C, the integrated bearing **40** is a cap **43** having the rod passage **41** at the rotational axis X. The transverse portion **45** of the cap **43** forms the thrust bearing $\mathbf{40}_T$. The cap **43** can be formed of low friction material.

As shown in FIG. **7**B, for use in the embodiments of FIGS. **2** and **4**B, the tubular portion **47** extends downwardly and is sized to accommodate the rod clamp **24**. The tubular portion **47** forms the radial bearing $\mathbf{40}_R$.

As shown in FIG. **7**C, for use in the embodiment of FIG. **5**B, the tubular portion **47** extends upwardly and is sized to accommodate the rod **20**.

As one of skill in the art would appreciate, bearings or bushing as described herein can be supported between the guard **10** and the polished rod assembly **12** in a number of

ways, including but not limited to being mounted on one or the other of the polished rod assembly **12** or to the guard **10**, without departing from the overall concept of the invention.

In embodiments, the guard **10** may be restrained and non-rotational during normal operation. The anti-friction interface F in the annulus **16** between the normally restrained guard **10** and the driven member **12** aids in rotation of the driven member **12** therein. Further, as in the various embodiments described above wherein the guard **10** has the larger diameter lower portion **32** and the upper smaller diameter portion **34**, the shape of the guard **10** also acts to minimize the size of the drive head **14**.

The embodiments in which an exclusive property or privilege is claimed are defined as follows:

1. A system for preventing entanglement by contact with a rotating rod assembly for driving a downhole pump, the system comprising:

a drive head having

a housing from which the rotating rod assembly extends, the rod assembly comprising a rotating rod and a rod clamp for operatively connecting the rotating rod to a main driven shaft extending upwardly from the housing and being rotatable therewith; and

a tubular guard positioned concentrically about the driven member, forming an annulus therebetween, the guard having a moment of inertia; and

an anti-friction interface within the annulus for enabling differential rotation between the guard and the driven member,

when, during normal operation, the safety guard is unrestrained, the guard is free to co-rotate with the driven member; and

when restrained by contact therewith, the moment of inertia enables rotation of the guard to cease rotation while the driven member continues to rotate therein.

2. The system of claim **1** wherein at least a material of manufacture of the guard forms the anti-friction surface.

3. The system of claim **2** wherein the material of manufacture is a plastic.

4. The system of claim **3** wherein the plastic is polytetrafluoroethylene.

5. The system of claim **1** wherein the anti-friction interface further comprises bushing or bearings or a combination thereof.

6. The system of claim **1** further comprising a drive operatively connected to the main shaft for driving the pump, the drive extending upwardly from the housing adjacent to the rod assembly; the drive encroaching on a clearance about the guard, the guard further comprising:

a lower portion sized to fit over the main shaft and the rod clamp;

an upper portion having a smaller diameter than that of the lower portion for fitting over the rod extending therefrom; and

a radial shoulder extending therebetween, the shoulder axially engaging the rod clamp for supporting the guard thereon.

7. The system of claim **1** further comprising a drive operatively connected to the main shaft for driving the pump, the drive extending upwardly from the housing adjacent to the rod assembly; the drive encroaching on a clearance about the guard, the guard further comprising:

a lower tubular member having:

a lower tubular portion having a diameter for fitting over at least the rod clamp and main shaft,

an upper tubular extension having a diameter for extending axially over at least a portion of the rod; and

a radially extending shoulder formed therebetween; and

an upper tubular member sized to fit over the upper tubular extension and the rod.

8. The system of claim **1** wherein the rod clamp further comprises an outer cylindrical surface for supporting the anti-friction interface thereon.

9. The system of claim **8** further comprising at least radial bearings mounted about the outer cylindrical surface for forming the anti-friction interface.

10. The system of claim **8** further comprising at least thrust bearings mounted in the annulus between a top of the rod clamp and the radial shoulder for accepting axial loading thereon.

11. The system of claim **1** wherein the rod clamp has a non-cylindrical cross-section, further comprising:

an adapter sleeve having an inner profile corresponding to the cross-section of the rod clamp and an outer cylindrical surface for supporting the anti-friction interface thereon.

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